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(54) Improved bass reproduction

(57) The housings of the loudspeaker is divided into two or three chambers V_1, V_2, V_3 by diaphragms M1, M2, M3. One of the inner volumes adjoins the diaphragm of the loudspeaker. Movements of an inner diaphragm M3, caused by pressure changes due to motion of the front diaphragm, are servo supported by an inner electrodynamic transducer TR2, whose diaphragm M2 lies in parallel behind the other inner diaphragm. The supporting movements are caused by a controller, which tries to hold constant the distance between the two inner diaphragms M2, M3.

In a further embodiment (Fig 2) the inner diaphragm M3 may be mounted upon the diaphragm M2 of the inner transducer. This arrangement dispenses with the third volume V3.

In another proposed embodiment the diaphragm M3 is disposed of and the distance between diaphragms M1, M2 is kept constant.

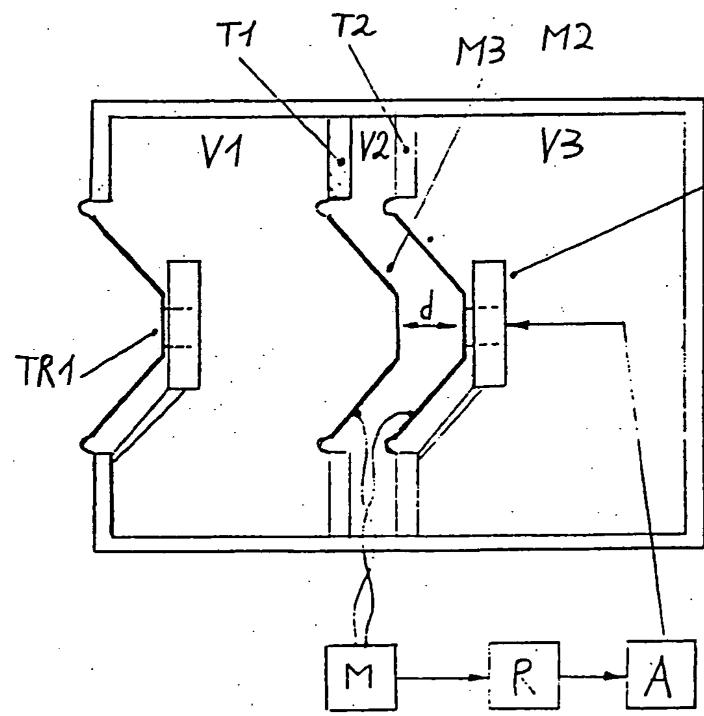

Diagram 1

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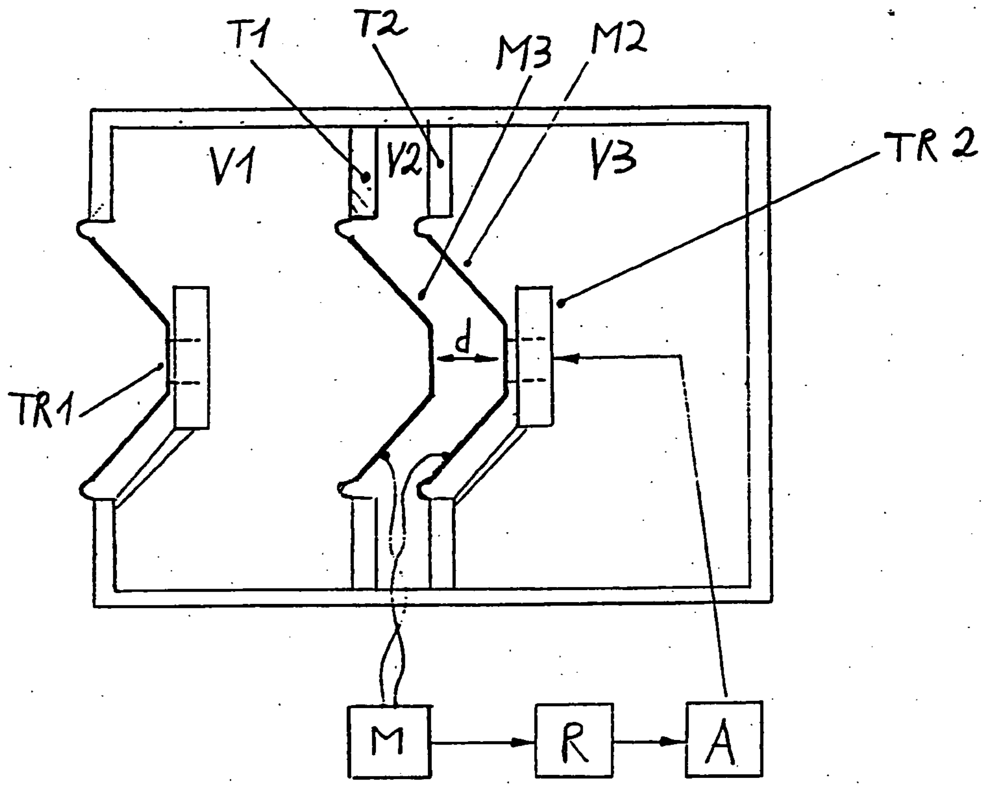

Diagram 1

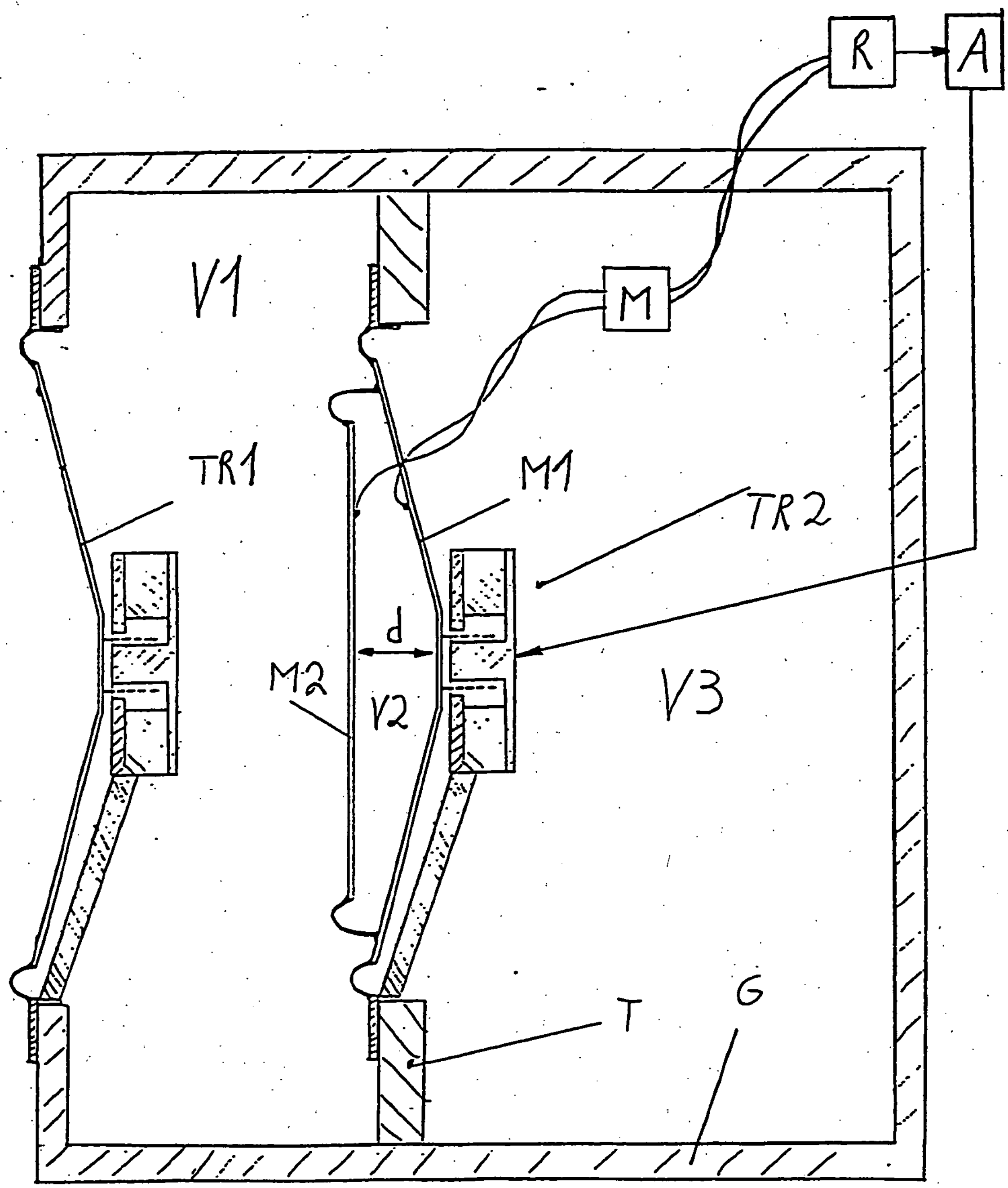

Diagram 2

Device to improve the bass reproduction in loudspeaker systems using closed housings.

Conventional loudspeaker systems have an inferior bass reproduction if the housings are small. In small housings air compression forces will build up and hinder the movement of the radiating loudspeaker`s membrane. These forces evolve from volume changes in the air inside the housing which are caused by the movement of the loudspeaker`s membrane. The membrane compresses or decompresses the air and the resulting forces hinder the movement of the membrane. Being elastic forces they also increase the resonance frequency of the system.

To achieve a satisfying bass reproduction large, impractical housings are used, or different kinds of resonant boxes are employed. Often the driving signals are corrected in their frequency characteristic, or the loudspeakers are controlled by servo systems. All these solutions cause distortions or are impractical to use, or show a poor pulse response.

Another known method (Tiefenbrun, US-Pat. 4008374) uses a second loudspeaker incorporated into the housing to simulate a larger volume.However this method just transfers the problems from the outer to the inner loudspeaker. To achieve satisfying results large housings must be used once again. Additionally, problems arise from distortions caused by phase differences between the movements of the membranes`.

The inventions as defined by the claims (1-4) improve the bass reproduction of loudspeaker systems with small housings and with large loudspeaker membranes. Neither a direct correction of the driving signals is used in the invented systems nor is a servo system for the radiating loudspeaker employed.

The above-mentioned results are achieved by the systems characterized by the claims 1 - 4. The invented systems are unique because of the fact that differences between the gas

pressure inside the housing and the time-averaged mean pressure outside the housing are almost eliminated by the movements of a servo controlled membrane inside the housing. This membrane is part of a servo control system. It even reacts to very weak forces upon it by relatively strong movements in the direction of these forces.

Diagram 1 shows a device as described in claim 1. The loudspeaker housing is divided into three chambers by two soundproof and almost pressure-tight walls, T1, T2. The first chamber, V1, is enclosed by the membrane of the outer, sound radiating loudspeaker, TR1, by parts of the housing, by the inner wall T1 and by an inner membrane M3. The stiff membrane M3 is built into an opening of the inner wall so that it separates the chamber V1 from the chamber V2. It can be displaced very easily. In parallel to this membrane an inner elektrodynamic transducer TR2 is placed in a hole of the second inner wall T2. Its membrane lies parallel to the other inner membrane in T1. Its distance from this membrane is small in comparison to the wavelength of acoustical low frequency waves. The diameter of the membrane M2 of the inner transducer is a little bit smaller than the diameter of the other inner membrane M3.

The changes of the distance between the two membranes are measured. This measurement is achieved by using inductive, capacitive, resistive or piezoelectrical methods. The diagram shows a capacitive sensor. An electronical circuit produces an electrical signal which is proportional to the changes in distance. This signal is forwarded to a controller, which is a PI-, PID or preferably a state controller. The output signal of the controller is amplified by a power amplifier which drives the inner transducer TR2. The controller is dimensioned to hold the distance between the two inner membranes always constant, i.e. changes of the distance are almost suppressed.

The preferred state controller controls the distance of the membranes and its derivatives as well as the position of the membrane M2 of the inner transducer and its derivatives. To

achieve the latter, the position of the membrane is measured also.

Because the effective areas of the two inner membranes are almost equal and because the distance between both stays constant, the gas pressure in the middle chamber V2 between the membranes stays almost constant too. This holds true despite displacements of the first inner membrane M3 caused by pressure changes in the chamber V1. The inner membrane reacts as if the inner volume V2 were very large. The edge of this membrane is attached very flexibly to the inner wall so that it can be easily displaced. Therefore, the pressure in the chamber V1 is kept almost constant too and the performance of the loudspeaker TR1 is not disturbed by compression effects.

The device described in claim 2 and shown by diagram 2 is similar to the above described device. However, the inner wall T1 has been ommited. The inner membrane M3 is attached directly to the inner transducer, the volume V2 is enclosed by the two membranes. This device allows building quite simple housings with only one inner partition. In addition to this the force which is necessary to displace the membrane M3 is even reduced because of its attachement to the membrane M2 instead of being connected to a fixed wall. Furthermore, the diameter of the two membranes need not be almost equal as in the device of claim 1.

Claim 3 describes how to build a capacititive sensor to measure the distance. The two inner membranes are covered with two conductive layers forming a condenser. The distance between the membranes is inverted proportional to the capacity which is measured.

Claim 4 claims the measurement of the position of the membrane of the inner electrodynamic transducer and the use of the measured value with a state controller circuit. By controlling the position of the membrane the dynamic behavior of the transducer`s membrane does not influence the other parts of the

system. The swinging of the transducer`s membrane is suppressed by the controller.

In claim 5 a device is described at which the pressure in the chamber V2 is measured rather than the distance between the inner membranes. For this measurement a cheap and simple, but effective piezoelectric pressure sensor made of polyvinylidene fluoride is used. The pressure is kept constant by the controller. The result is the same as with the above-mentioned devices.

The subject of claim 6 is a device with only one inner partition and one inner membrane which is part of a electrodynamic transducer. The diameter of the inner membrane is a little bit smaller than that of the outer membrane. The distance between the outer loudspeaker`s membrane and the inner membrane is measured and kept constant by a controller which drives the inner membrane. By doing this, a large inner volume is simulated.

Description of the diagrams

The diagrams 1 and 2 show devices which are described by the claims 1 and 2.

Diagram 1. The volume inside the loudspeaker housing G is divided into three chambers V1, V2, V3 by two walls T1, T2. The inner membrane M3 is built into the wall T1, the inner transducer TR2 with its membrane M2 is mounted in an opening of the wall T2. TR1 is the outer loudspeaker.

Diagram 2 The volume inside the housing G is divided by the wall T into two chambers V1, V3. The inner transducer TR2 is built into the wall T. The membrane M2 is connected with the membrane M1. The two membranes enclose the volume V2. The distance d of the two membranes is measured by the device M and is kept constant by the controller R, the amplifier A and the transducer TR2. The loudspeaker TR1 adjoins the volume V1.

Claims

1. Device for improving bass reproduction by loudspeaker systems with closed housings, characterized by the claimed traits, that the inner volume of the acoustically closed housing (G) is divided into three chambers (V1, V2, V3) by two stiff, soundproof and almost pressure-tight walls, that the first chamber is enclosed by the membrane of the loudspeaker (TR1), the first wall (T1) and parts of the enclosure (G), that the second chamber is built up by the two inner walls and parts of the enclosure, that the third chamber is enclosed by the second inner wall (T2) and parts of the housing, that a light, stiff and almost pressure-tight membrane (M3) is built into an opening of the first inner wall in a way, that this membrane separates the first and the second inner chamber (V1, V2), that this membrane is connected to the wall by a flexible material to enable it to move, that an electrodynamic transducer (TR2) is built into the second inner wall (T2) in a way, that its almost pressure-tight membrane (M2) separates the second and the third chamber, that the diameter of the inner transducer`s membrane is smaller than that of the other inner membrane (M3), that the two inner membranes lie in parallel to each other, that changes of the distance between the two inner membranes are measured by optical, inductive, capacitive, resistive or piezoelectrical means and a proportional electrical signal is produced, that this signal is applied to an electrical controller (R), that the controller steers a power amplifier (A) which drives the inner transducer (TR2), and that the controller is dimensioned in a way, that the distance between the two inner membranes is kept almost constant at all times.

2.) Device for improving bass reproduction by loudspeaker-systems with closed housings, characterized by the claimed traits, that the inner volume of the housing is divided by a soundproof and almost pressure tight (T) wall into two chambers (V1, V3), that the first chamber is enclosed by the membrane of the loudspeaker (TR1), the first wall (T1) and parts of the

enclosure (G), that the second chamber is enclosed by the inner wall (T1) and parts of the housing, that an electrodynamic transducer (TR2) is built into that inner wall in a way, that its main membrane (M1) separates the two chambers from each other, that a second, smaller, soundproof and almost pressure-tight membrane (M2) is attached at its edge to the main membrane in such a way, that a third chamber (V3) is enclosed by the two membranes, that the second membrane is connected with the main membrane by a flexible, pressure-tight material to enable it to move, that this second membrane adjoins the first chamber (V1), that changes of the distance between the two inner membranes are measured by optical, inductive, capacitive, resistive or piezoelectrical means and a proportional electrical signal is produced, that this signal is applied to an electrical controller (R), that the controller steers a power amplifier (A) which drives the inner transducer (TR2), and that the controller is dimensioned in a way, that the distance between the two inner membranes is kept almost constant at all times.

3.) Device according to the claims 1 or 2, characterized by the claimed traits, that the surfaces of the two inner membranes, which lie opposite each other, are coated with an electrically-conducting material in such a way, that the two layers form a condenser with a capacitance inversely proportional to the distance between the two membranes, that changes of the capacitance are measured and a proportional electrical signal is produced, and that this signal is forwarded to the controller.

4.) Device according to the claims 1 - 3, characterized by the claimed traits, that the position of the inner transducer`s membrane (M2) is measured, that the controller is a state controller, and that the controlled items are, firstly, the distance of the two inner membranes and their derivatives, and, secondly, the position of the inner transducer`s membrane and its derivatives.

5.) Device according to the claims 1 - 4, characterized by the claimed traits, that in the inner chamber, which is enclosed by the two inner membranes, a pressure sensor is placed to measure the gas pressure in this chamber, that this pressure sensor is made of polyvinylidene fluoride or other piezoelectric materials, that the sensor is attached to one of the inner membranes, that the sensor produces in conjunction with a measurement circuit an electrical signal proportional to pressure changes in the chamber, that this signal is applied to an electrical controller (R), that the controller steers a power amplifier (A) which drives the inner transducer (TR2), and that the controller is dimensioned in a way, that the pressure is kept almost constant at all times.

6.) Device for improving bass reproduction by loudspeaker-systems with closed housings, characterized by the claimed traits, that the inner volume of the housing is divided by a soundproof and almost pressure-tight wall (T1) into two chambers, that an electrodynamic transducer (TR2) is built into the inner wall in a way that its membrane (M2) separates the two chambers from each other and that the membrane (M2) lies parallel to the membrane of the loudspeaker (TR1) built into the enclosure, that the diameter of the inner membrane is smaller than that of the loudspeaker`s membrane (M1), that changes of the distance between the two membranes are measured by optical, inductive, capacitive, resistive or piezoelectrical means and a proportional electrical signal is produced, that this signal is applied to an electrical controller (R), that the controller steers a power amplifier (A) which drives the inner transducer (TR2), and that the controller is dimensioned in a way, that the distance between the two membranes is kept almost constant at all times.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

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Relevant Technical fields

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(ii) Int Cl (Edition 5) H04R 1/20, 1/22, 1/28, 3/00

Search Examiner

P J EASTERFIELD

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASES: WPI

Date of Search

25 NOVEMBER 1992

Documents considered relevant following a search in respect of claims

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	GB 2122051 A (GOODMANS)	
A	WO 91/15933 A1 (HOBELSBERGER)	

Category	Identity of document and relevant passages	Relevant to claim(s.

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E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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